

REMARKS/ARGUMENTS

Claims 1, 2, 7-9, 11-13, and 15-18. Claim 15 has been withdrawn from further consideration by the Examiner as directed to an invention nonelected in response to a restriction requirement. Claims 1, 11, 17, and 18 are currently amended.

Claims 1, 11, 17, and 18 are currently amended to clarify that the Al concentration layer has an average Al concentration in the range indicated in each claim. Support therefore is found in the Specification at page 13, first full ¶. Claims 1, 17, and 18 are also currently amended to limit the Al content between the Ti-Al alloy and the oxide layer to 25% or less in Claim 1, 16% or less in Claim 17, and 6% or less in Claim 18. Support therefore is found in Figure 3 which depicts a composite layer 3 between the Ti-Al alloy 1 and the oxide layer 2, and in the Specification at page 11, line 1, to page 13, line 11. Note particularly the Specification's disclosure that the layer may be formed in one piece between the bulk part 1 comprising the Ti-Al alloy and the oxide film 2, as shown in Fig. 3 (Spec., p. 11, first full ¶). The Specification teaches (Spec., pp. 11-12, bridging ¶):

[I]f the Al content of the Al concentration layer exceeds 25%, a very brittle  $\gamma$  phase based on Ti-Al is produced, and the surface layer (Al concentration layer and oxide film) easily cracks and peels during working. As hydrogen infiltrates from cracked or peeled parts of the surface layer, the hydrogen diffusion blocking effect is no longer observed. For this reason, it is desirable to suppress the Al content of the Al concentration layer to 25% or less. Further, it is preferably 16% or less which is the component range wherein a  $\epsilon$  phase is not produced, and more preferably 6% or less which is the component range at which an  $\alpha_2$  phase ( $Ti_2Al$ ) is not produced.

Accordingly, no new matter is added.

Rejections under 35 U.S.C. 103 over Miyamoto in view of Grunke, Lütjering, and Yao

Previously presented Claims 1, 2, 7, 9, 11-13, and 16-18 were rejected under 35 U.S.C. 103 over Miyamoto (EP 1 126 139 A2, published August 22, 2001) in view of Grunke (U.S. Patent 4,936,927, issued Jun 26, 1990), Lütjering (Lütjering et al., Titanium, Springer-Verlag, Berlin, 2003; pp. 48-49, para. 2.9.3; Fig. 2.32), and Yao (U.S. Patent 6,066,359, issued May 23, 2000). Office Action dated October 5, 2009 (OA), page 3, paragraph 5. In

light of Applicant's current amendments to Claims 1, 17, and 18, the rejections should be withdrawn.

Applicant's Specification teaches that the Al content of the Al concentration layer between the core Ti-Al alloy and the outer oxide film (Figure 3) must be 25% or less, preferably 16% or less, more preferably 6% or less. If the Al content of the Al concentration layer between the core Ti-Al alloy and the outer oxide film (Figure 3) exceeds 25%, the outer surface layer (Al concentration layer and oxide film) cracks and peels and the hydrogen diffusion blocking effect of the surface layer is no longer observed (Spec., pp. 11-12, bridging ¶).

While Miyamoto teaches that a titanium alloy comprising 0.5-2.3% by mass of Al has superior heat-resistance, oxidation-resistance, and weldability, Miyamoto does not teach that its superior heat and oxidation-resistant titanium alloy is also resistant to hydrogen diffusion and the deterioration resulting therefrom. Miyamoto does not teach that its superior titanium alloy should be covered by an oxide film and most certainly does not suggest that the superior titanium alloy should be covered by a surface layer comprising both a higher Al concentration layer and an outermost oxide film (OA, pp. 4-5).

With those deficiencies in mind, the Examiner relies on Grunke for its teaching to apply a higher Al concentration layer over a Ti-Al alloy (OA, p. 4, 1<sup>st</sup> full ¶). Then, Lütjering is cited for its teaching that "Al<sub>2</sub>O<sub>3</sub> and crystalline TiO<sub>2</sub> naturally form on titanium aluminides that have been exposed to air" and that the natural "oxides . . . are responsible for the oxygen resistant nature of titanium-aluminum alloys" (OA, pp. 4-5, bridging ¶). Yao is cited for its teaching to form a thin crystalline titanium oxide film over a metal, ceramic, or polymeric substrate to protect the substrate from oxidation and thus enhance its corrosion resistance (OA, p. 5, first full ¶). Based on the combined teachings, the Examiner concludes that Applicant's claimed titanium alloy material would have been obvious to a person having

ordinary skill in the art. Applicant believes the Examiner erred in concluding that the currently claimed titanium alloy material would have been obvious over the applied prior art for the following reasons.

First, while Grunke appears to teach the formation of a layer of higher Al concentration in the range of from 0.8-25 mass% over a Ti-Al alloy, that layer is but one layer of a composite of higher Al concentration layers formed on the core Ti-Al alloy. Applicant's currently amended claims require an outermost oxide film on the Ti-Al alloy having a thickness of 1.0-100 nm which is produced by a process comprising oxidizing the Ti-Al alloy and an Al concentration layer between the Ti-Al alloy and the oxide layer wherein the Al content between the Ti-Al alloy and the oxide layer is 25% or less in Claim 1, 16% or less in Claim 17, and 6% or less in Claim 18. The possibility that one of Grunke's layers on the Ti-Al alloy and between the Ti-Al alloy and a naturally formed oxide layer might be a higher Al concentration layer with an Al content of 25% or less as in Applicant's Claim 1, might be a higher Al concentration layer with an Al content of 16% or less as in Applicant's Claim 17, or might be a higher Al concentration layer with an Al content of 6% or less in Claim 18, is immaterial to the subject matter Applicant claims unless the Al content between the Ti-Al alloy and the oxide layer is 25% or less as required by Claim 1, the Al content between the Ti-Al alloy and the oxide layer is 16% or less as required by Claim 17, or the Al content between the Ti-Al alloy and the oxide layer is 6% or less as required by Claim 18. According to Applicant's current claims, the Al content between the Ti-Al alloy and the oxide layer must be 25% or less, 16% or less, or 6% or less irrespective of the fact that one of at least three Grunke's layers between the Ti-Al alloy and any naturally formed oxide layer may have an Al content of 25% or less, 16% or less, or 6% or less.

As calculated by the Examiner, Grunke teaches that the Al content of the  $\text{TiAl}_2$  layer between the Ti-Al alloy and the oxide layer is approximately 53%, the Al content of the TiAl

layer between the Ti-Al alloy and the oxide layer is approximately 36%, and the Al content of the  $\text{Ti}_3\text{Al}$  layer between the Ti-Al alloy and the oxide layer is approximately 16% (OA, p. 7; *Calculation of Percentage Al in Various Ti and Al Compounds*). Thus, the average Al concentration of Grunke's at least three layers between the Ti-Al alloy and the oxide layer appears to be approximately 35%. Applicant's Specification teaches that the Al content between the Ti-Al alloy and the oxide layer cannot exceed 25% or cracking, peeling, and hydrogen diffusion will result and deterioration of the Ti-Al alloy will occur (Spec., pp. 11-12, bridging ¶).

Grunke's object is to protect a Ti-Al alloy against oxygen embrittlement (Grunke, col. 3, ll. 1-12). To do so, Grunke instructs (Grunke, col. 34-39):

[A] layer is formed having a high aluminum content and comprising, as a rule, the intermediate phase  $\text{TiAl}_3$ , whereby the aluminum content still decreases with a jump at the transition or boundary between the protective coating and the titanium or titanium alloy of the structural component.

Grunke continues (Grunke, col. 3, ll.52-61):

The phase first formed is normally  $\text{TiAl}_3$ . The phases formed in the second step are, for example,  $\text{TiAl}_2$ ,  $\text{TiAl}$ , and  $\text{Ti}_3\text{Al}$ . . . . The aluminum content thus diminishes in a stepwise manner from the surface in the direction toward the core of the structural component.

Grunke's Figure 2a best illustrates the resulting coating. Grunke states (Grunke, col. 6, ll. 16-26; emphasis added):

FIG. 2a illustrates a coating on a structural component which has been prepared as a result of a short duration diffusion treatment or diffusion annealing in which a number of layers having different intermetallic phases have been formed. For example, the outermost surface layer to the left in Fig. 2a is a  $\text{TiAl}_2$  layer, the next layer inwardly is a  $\text{TiAl}$  layer. The third layer is a  $\text{Ti}_3\text{Al}$  layer, and the fourth layer includes the titanium aluminum mixed crystal. As a result, the aluminum content diminishes from the outer surface inwardly in steps as shown at 2 in FIG. 2b.

Based on the Examiner's calculations (OA, p. 7), even if persons having ordinary skill in the art were to presume that the fourth layer in Grunke's Fig. 2a has an Al content of 0%, the average Al concentration of Grunke's four layers between the Ti-Al alloy and the oxide layer

appears to be approximately 26% which is lower than the Al content of 25% or less required between the Ti-Al alloy and the oxide layer by Applicant's currently amended Claim 1.

Moreover, Lütjering and Yao do not support the Examiner's case for obviousness due to optimization. Like Grunke, Lütjering and Yao are concerned with improving the oxidation resistance of a Ti-Al alloy or other metallic surface. While Lütjering suggests that titanium aluminides are indeed naturally oxidized, Lütjering also teaches that oxidation resistance is improved by increasing the aluminum concentration to around 40 at% Al (Lütjering, pp. 49-50, bridging ¶):

The improved oxidation resistance of titanium aluminides, such as  $Ti_3Al$  or  $\gamma$ -TiAl based alloys, results from an increased volume fraction of  $Al_2O_3$  in the scale (Fig. 2.32). The amount of  $Al_2O_3$  increases with aluminum concentration and the  $Al_2O_3$  layer becomes continuous around 40 at% Al. Consequently,  $\gamma$ -TiAl exhibits a better oxidation resistance than alloys based on  $Ti_3Al$ . This is because  $TiO_2$  is not stable on titanium alloys at high temperatures and the  $Al_2O_3$  layer is not continuous on  $Ti_3Al$  (Fig. 2.32), whereas the  $Al_2O_3$  layer is continuous on  $\gamma$ -TiAl and stable up to much higher temperatures. This improved oxidation resistance can be used for the development of surface coatings for conventional titanium alloys . . . .

Persons having ordinary skill in the art would have learned from Lütjering's teaching to increase the Al content between Grunke's Ti-Al alloy and a natural oxide layer to improve the oxidation resistance of a Ti-Al alloy as Miyamoto, Grunke, Lütjering, and Yao all seek to do. Persons having ordinary skill in the art reasonably would not have reduced the Al content between Ti-Al alloy and any naturally formed oxide layer to 25% or less to improve oxidation resistance. On the other hand, Applicant's purpose for decreasing the Al content between the Ti-Al alloy and the oxide layer of its claimed titanium alloy material to 25% or less is to improve its resistance to hydrogen diffusion, unlike the collective purposes of Miyamoto, Grunke, Lütjering, and Yao to improve oxidation and heat resistance. The subject matter Applicant claims would not have been obvious in view of the combined prior art teachings.

Moreover, Yao forms a thin titanium oxide layer on a metallic surface to improve oxidation resistance. Lütjering teaches that  $\text{TiO}_2$  is not stable on titanium alloys at high temperatures (Lütjering, pp. 49-50, bridging ¶). Yao's teaching is not directed, and does not relate, to an oxide film comprising 50 mass% or more of a crystalline oxide produced by oxidizing the Ti-Al alloy on a Ti-Al alloy substrate. In addition, Yao's titanium oxide layer is produced by a significantly different method from a solution of containing titanium fluoro complex compounds.

The Examiner states that persons having ordinary skill in the art would have appreciated the positive effects of applying an aluminum coating on the alloy of Miyamoto to further enhance its oxidation resistance (OA, pp 7-8, bridging ¶). While that broad statement might be true, in light of Lütjering's combined teaching, persons having ordinary skill in the art would not have decreased the Al content below 40 at% (Lütjering, pp. 49-50, bridging ¶) and most certainly would not have suppressed the Al content between the Ti-Al alloy core and the surface oxide film to an Al concentration of 25% or less as Applicant's Specification teaches (Spec., pp. 11-12, bridging ¶) and Applicant's currently amended claims require.

The Examiner concludes that Applicant's previously presented claims required "approximately 15.8% by mass in at least some portion of the coating" (OA, p. 8, 1<sup>st</sup> full ¶). Applicant's current claims require an Al content between the Ti-Al alloy and the oxide layer of 25% or less. Grunke's combination of layers between the Ti-Al alloy and the oxide layer has an Al content of at least 26%, and Lütjering would have taught persons having ordinary skill in the art that an Al content of 40 at% is preferred for optimum oxidation resistance of Ti-Al alloys.

The Examiner argues that oxidation resistance may always be improved (OA, p. 8, 2<sup>nd</sup> full ¶). However, Applicant's invention is concerned with improving the resistance of Ti-Al

alloys to hydrogen diffusion, not oxidation resistance. Grunke and Lütjering would have led persons having ordinary skill in the art away from an Al content below 40 at%.

Finally, the Examiner appears to acknowledge that Yao teaches away from Applicant's claimed invention and therefore substitutes Lütjering's teaching that Ti-Al alloys are inherently oxidized in ambient air (OA, p. 8, last ¶). Lütjering confirms that Yao's titanium dioxide layer is not stable on titanium alloys at high temperatures (Lütjering, pp. 49-50, bridging ¶). On the other hand, the Examiner has not explained how Lütjering's suggestion that a Ti-Al alloy is naturally or inherently oxidized would have led persons having ordinary skill in the art to reasonably expect formation of oxide films comprising 50 mass% or more of a crystalline oxide, most especially Brookite as in Claims 9 and 12, to a thickness of 1.0 - 100 nm over a Ti-Al alloy with an Al concentration layer thereon. The Examiner's finding of inherency based on Lütjering's teaching does not support her case for obviousness.

The prior art teachings away from the invention Applicant currently claims provides strong evidence of unobviousness. *KSR Int'l. Co. v. Teleflex Inc.*, 550 U.S. 398, \_\_\_\_ (2007). The Examiner's rejections under 35 U.S.C. 103 fairly should be withdrawn.

#### Rejection of Claim 8 under 35 U.S.C. 103

Previously presented Claim 8 was rejected under 35 U.S.C. 103 over Miyamoto in view of Grunke, Lütjering, Yao, and Kobayashi (EP 0 816 007 A2, published January 7, 1998)(OA, p. 6, ¶6). The rejection should be withdrawn.

Kobayashi does not cure any of the deficiencies or teachings away in Miyamoto, Grunke, Lütjering, and Yao. Moreover, persons having ordinary skill in the art would not have been led by the combined teachings of Miyamoto, Grunke, Lütjering, Yao to improve the oxidation and resistance of the titanium aluminide alloys described by Miyamoto by application of surface layers which impart inferior oxidation and heat resistance to the alloys

for welding heat resistant titanium aluminide to a steel member in accordance with Kobayashi's instructions. Kobayashi would have instructed persons having ordinary skill in the art to weld heat resistant Ti-Al alloy to steel. It is inconceivable that the ordinary artisan would coat a heat and oxidation resistant alloy with layers which impart inferior heat and oxidation resistance in order to further improve Kobayashi's method of friction-welding a steel shaft to a heat resistant Ti-Al alloy. The rejection is unreasonable and should be withdrawn.

For the reasons stated herein, Applicant's claims are allowable over the applied prior art and in condition for allowance. Early Notice of Allowance is respectfully requested.

Respectfully submitted,

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